



Development of a UL Standard for the Utility Interconnection of DG Products Subcontract Number: NAD-1-30605-2

Principal Investigator: Tim Zgonena, Underwriters Laboratories
NREL Technical Monitor: Benjamin Kroposki

Electric Distribution Transformation Program

**2004 Annual Program and Peer Review Meeting,
October 28-30, 2003, Coronado (San Diego), California**

Present North American Utility Grid and DG

(Current Practice)

- Traditional utility electric power systems were designed to support a one way power flow from the point of generation through a transmission system to distribution level loads.
- These systems were not originally intended to accommodate the backfeed from Distributed Generation DG active generation at the distribution level.

Electric Utilities Needs and Concerns Regarding DG

- Reliable Power Grid Operation
- Protection Against Faults
- Power Quality
- Impact on Utility Monitoring and Switching Equipment
- Impact on Other Utilization Equipment.
- Liability Problems Related to the Above Items

Incompatibility Problem

- Utilities want an assurance that interconnected DG equipment will operate properly after it is manufactured and after years of service in the field.
- Most established utility test methods and test equipment, historically used to test utility protective relays, are not compatible with the new microprocessor-based interconnected DG equipment.



Resulting Situation for DG Equipment

- Most utilities and state utility commissions are proceeding very cautiously
- Creation of individual utility or state DG interconnection requirements, which are used to closely evaluate installations of DG products.
- DG products and installations are regularly subjected burdensome investigations by a variable cast of regulators.

I've got a Photovoltaic project in downtown Madison, Wisconsin near the State Capitol. This area is served electricity from my company's low-voltage 208 Volt network system.

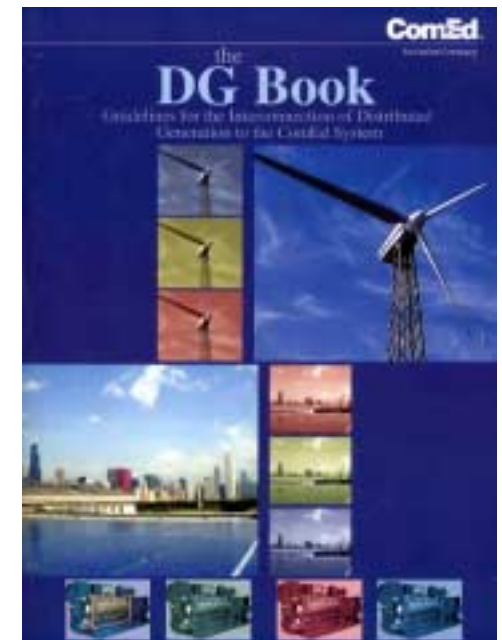
In the process of evaluating the SMA 2500 U inverter were there any tests simulating operation on a low-voltage network system?

Please call with questions.

Thank you,

Senior Engineer

Madison Gas and Electric Company

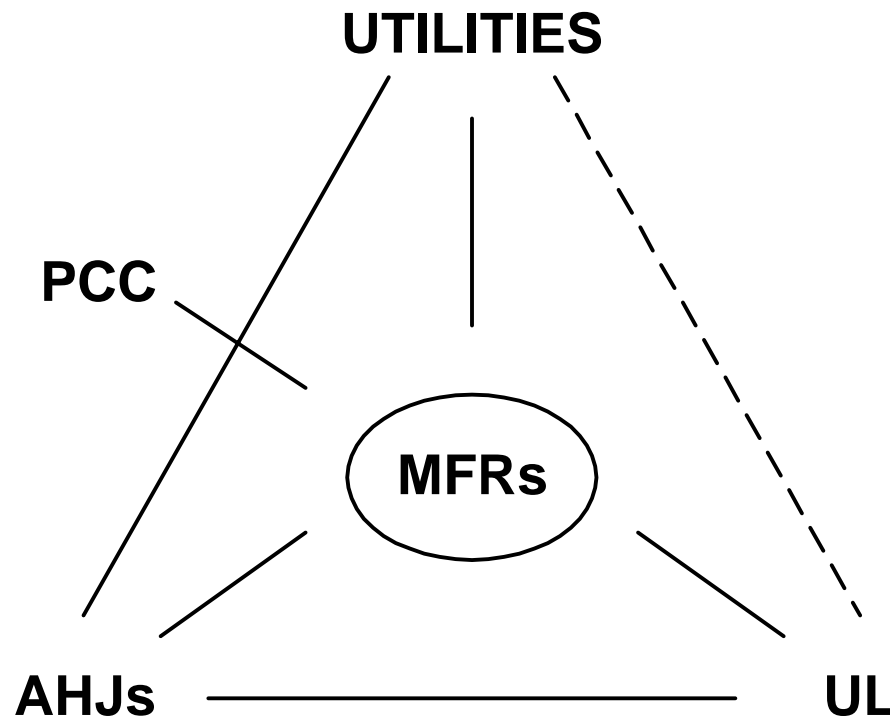


DG Product Safety Evaluations

Product Safety

- Electrical inspectors use the National Electric Code (NEC) or an augmented version of the NEC.
- Arts. 690 (PV), 692 (Fuel Cells) specifically call for utility-interactive equipment to be listed.
- Typically, unfamiliar equipment is required by the local inspector to be listed.
- Listing handled by a National Recognized Testing Laboratory (NRTL).
- Listing evaluations best done early into production design, to avoid building-in problems.
- Listing may not be suitable for handling installation-specific concerns.
- Listing may not be recognized by local utility authority as meeting their concerns.

How Does This All Add Up?



- Presently, manufacturers and installers of DG products have a difficult time getting their products installed, connected to the utility grid, and operating.

Project Objective / Technical Approach

- Under this contract, we are using the Standards Technical Panel (STP) process to combine UL's safety and utility interconnection requirements with those in the published IEEE 1547 standard.
- Result is an ANSI standard that can be used to evaluate utility interconnected DG products to address the needs of Electrical AHJ's and Utility Interconnection Engineers

Ultimate Goal

- This work will facilitate a streamlined system with identifiable, nationally common tasks and goals under which utility interconnected DG products may be designed, produced, evaluated, certified, sold, installed and operated in a smooth and agreeable manner for all parties involved.

Base Year / 2001 Tasks Completed

- Situation Analysis
- NEC and Other Interconnection Document Review and Report
- Create STP Meeting Agenda and Assemble a Balanced UL1741 STP
- Host the STP Meeting
- Create STP Meeting Report
- Annual Report Draft
- April 23, 2001
- May 31, 2001
- Oct 9, 2001
- Nov 7-9, 2001
- Dec 11, 2001
- Jan 16, 2001

OPTION YEAR 1 DELIVERABLES

- **D-2.2 (Task 6):** Progress Report on the Rough Draft.
- **Completed May 31, 2002.**

- **D-2.3 (Task 7):** Report on Comments to Rough Draft.
- **Completed September 27, 2002.**

- **D-2.4 (Task 8):** Progress Report on the Second Draft
- **Completed November 1, 2002.**

- **D-2.5 (Task 9):** Report on comments to the Second Draft.
- **Completed December 30, 2002.**

- **D-2.6 :** Annual Report.
- **Completed February 1, 2003.**

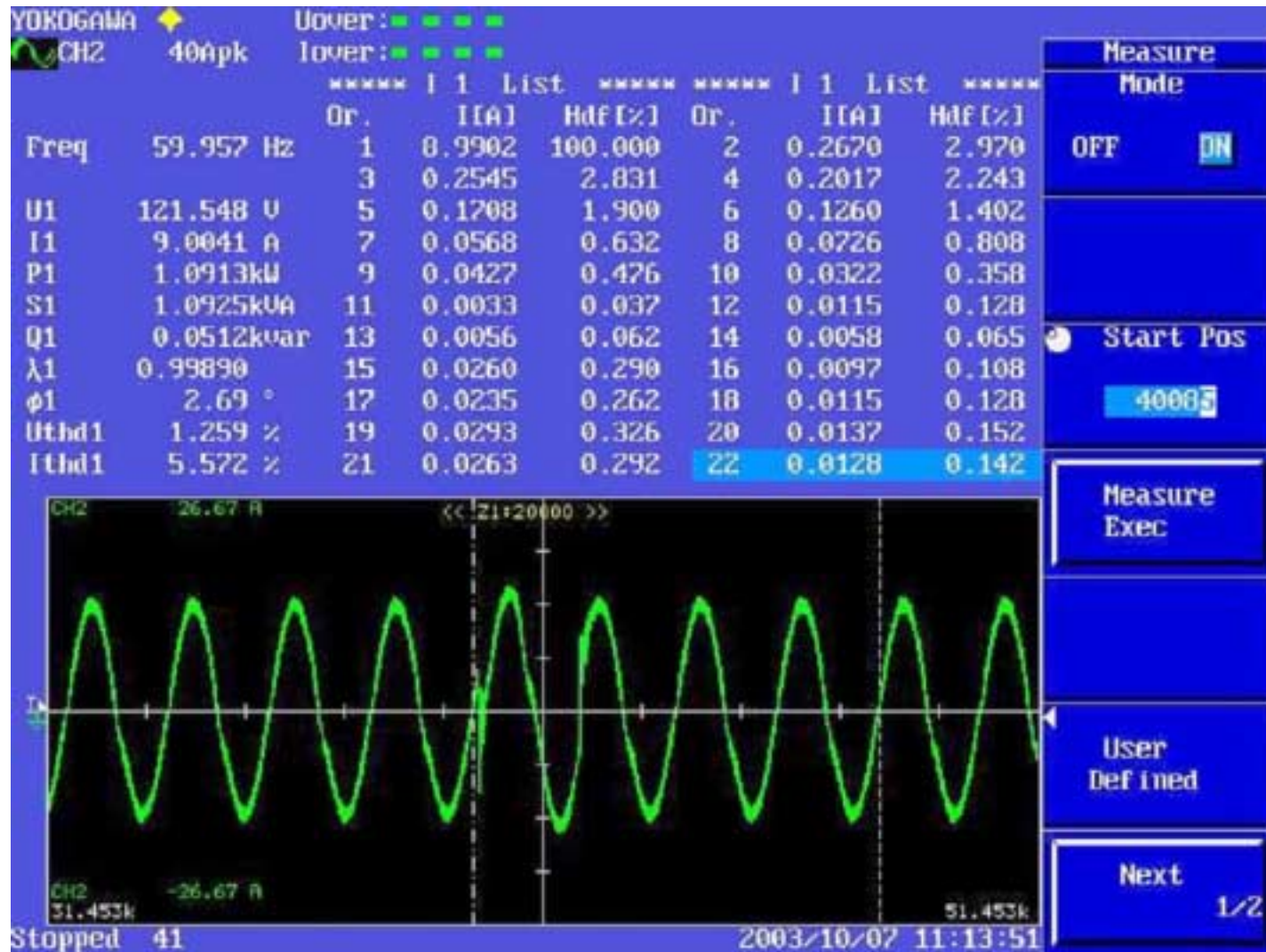
FEBRUARY THROUGH JULY 2003

- Option Year 2 of the subcontract was not formalized in mid-July 2003 due to a delay in DOE funding allocations. As such the work schedule was modified to accommodate the change in subcontract timing. Despite this delay UL continued work on this project.

FY03 Progress- DG Interconnection Testing

- The limits of higher order harmonics presently specified in most interconnection requirements are outside of the specified accuracy requirements of normally available test equipment.
- The measurement and data processing methods of commonly available test equipment conflict with many anti-islanding schemes and can result in measurement inaccuracies.
- Research into resolving these measurement issues is resulting in modification to both UL1741 and IEEE P1547.1.

FY03 Progress- DG Interconnection Testing



Sample Data from UL Testing

FY03 Progress- DG Interconnection Testing



UL Testing for Harmonics

FY03 Progress- DG Interconnection Testing

Order

Fixed

Repeat N times

Repeat 10

Tests: 60

Time: 1:00.00

State: Discharged

Time Between Tests

60

Sec Idle

Voltage

Mode: Fixed

Polarity: Alt 1

6000 V

Surge

Network: E522

Waveform: 1.2/50, 8/20 Comb 2 Ohm

Mode: Fixed

Coupling

Coupler: E522C

Mode: List

Start of List

1	L1+	L2	L3	N -	PE
2	L1+	L2	L3	N	PE-

Insert

Delete

Phase

Mode: Fixed

Ref: L1

90 dg

Measurement:

	Limit+	Peak+	Limit-	Peak-	
E522C A-B		71		-2	V
L1		8		-77	A

Run Stop

EUT power ON

Exit



UL Surge Testing

FY03 Progress- DG Interconnection Testing

Inductive Load Bank for Islanding Test



Capacitive Load Bank for Islanding Test



PLANNED OPTION YEAR 2 DELIVERABLES

- **D-3.2 (Task 10): Progress Report on the 3rd Draft. Due Sep 1, 2003**
- **D-3.3 (Task 11): Report on comments to the 3rd Draft. Due Nov 30, 2003**
- **D-3.4.(i) (Task 12): Interim Report on test equipment. Due Nov 30, 2003**
- **D-3.4.(ii) (Task 12): Final Report on test equipment. Due Feb 28, 2004**
- **D-3.5 (Task 13): Report on validation of test facilities. Due June 8, 2004**
- **D-3.6 (Task 14): Report on witness testing. Due July 15, 2004**
- **D-3.7 Final Report. Due August 30, 2004.**

Life-Cycle Project Budget

	Total (\$K)	DOE/NREL	UL Cost Share
Base Year	276	169	107
Option Year 1	392	169	223
Option Year 2	215	121	94
Total	883	460	424

Additional Related Standards Work

- Publication of both the IEEE P1547 and IEEE P1547.1 is crucial to the success of this project.
- Contract PI is responsible for the maintenance of UL1741 and is a member of the writing committee for both the IEEE P1547 and IEEE P1547.1 documents.
- The need for these documents has driven both these writing committees to maintain the same fast track pace as the IEEE 1547 working group.
- Many UL1741 STP members are also WG members of the IEEE 1547.1 document to ensure consistency between these two documents.

Interactions & Collaborations

- NREL
- SANDIA NATIONAL LABS
- NYSERDA
- CALIFORNIA ENERGY COMMISSION
- LIPA / KEYSPAN
- ENDECON
- BALLARD POWER SYSTEMS

Additional Testing Research and Collaborations

- Working with OEM to design a 250KW simulated utility for DG testing.
- Collaboration with Sandia Labs on the Harmonic Distortion testing and Anti-Islanding Testing.
- Implementation of the Anti-Islanding Test loads for larger three phase products
- Researching DG Test equipment for data acquisition automation.
- Performing Feasibility Study with NREL on LC simulator.

Impacts and Benefits

- This combination of requirements will yield a DG ANSI Standard that can be used to evaluate utility interconnected DG products for both electrical safety and utility interconnection to address the needs of Electrical AHJs and Utility Interconnection Engineers.
- This help will standardize interconnection procedures and requirements for DG owners.
- This should lead to reduce interconnection costs.

Contact Information

Tim Zgonena

Underwriters Laboratories Inc.
333 Pfingsten Rd.
Northbrook, IL 60062

847-272-8800 ext. 43051
timothy.p.zgonena@us.ul.com